# STACKED PLATE HEAT EXCHANGER WITH INTEGRATED CONNECTOR

## Field of the Invention

This invention relates to heat exchangers, and in more particular applications, to stacked plate heat exchangers wherein at least one integrated connector is drawn from a substantially flat end plate at an acute angle.

## Background of the Invention

Housing-less heat exchangers, such as stacked plate heat exchangers are often utilized for transferring heat between fluids as is known in International Patent Application WO 98/59208 A1 and EP 893 667B1. Stacked plate heat exchangers are often utilized in situations that require compact sizes, such as in engine compartments of automobiles. Even if the plates in such heat exchangers are designed to be compact, the overall heat exchanger system may still require excessive space because of the space requirements of the connections for flow inlets, outlets, and other plumbing necessary for heat exchanger operation.

The connections illustrated in WO 98/59208 A1 extend perpendicularly from the plane of the cover plate. Therefore, the inlet flows and outlet flow must extend perpendicularly from the cover plate, thereby increasing the overall height dimension of the heat exchanger system. Such designs are not advantageous when compact arrangements are desired.

The connections illustrated in EP 893 667B1 extend away from the outer

circumference of the housingless heat exchanger parallel to the plane of the associated cover plate. This increases the width dimension of the heat exchanger system.

Summary of the Invention

In accordance with one form of the invention, a stacked plate heat exchanger is provided for transferring heat between at least a first fluid and a second fluid. The stacked plate heat exchanger includes a first end plate having at least one fluid connector drawn from and arranged on the first end plate, a second end plate located opposite the first end plate, at least one intermediate plate sandwiched between the end plates to provide a surface area for transferring heat between the first and second fluids, and a fluid line. The connector has a first cross sectional plane located at a first port of the connector and a second cross sectional plane located at a second port of the connector, the first and second planes forming an acute angle relative to each other. The fluid line is attached to the connector at the second port to direct one of the first and second fluids between the connector and a component other than the connector.

In accordance with one form, the at least one intermediate plate includes a stack of intermediate plates sandwiched between the end plates to provide surface areas for transferring heat between the first and second fluids.

In one form, the fluid line is located at least partially above and extends over the first end plate.

In one form, the fluid line is arranged roughly parallel to the first end plate.

According to one form, the stacked plate heat exchanger further includes an auxiliary support to secure the fluid line to the first end plate.

According to one form, the first end plate includes a deformation having a shape that conforms with at least part of said auxiliary support to position the auxiliary support on the first end plate.

In accordance with one form, the auxiliary support is soldered to the first end plate and the fluid line.

In one form, the auxiliary support is formed as an integral piece of the first end plate.

According to one form, the acute angle is preferably between 10 and 70 degrees.

In accordance with one form, the fluid line is received in the second port of the connector and soldered thereto.

According to one form, the fluid line surrounds the second port of the connector and is soldered thereto.

In one form, the stacked plate heat exchanger further includes a vent located on the first end plate for venting one of the fluids.

In accordance with one form, the stacked plate heat exchanger further includes at least one fluid manifold defined by the at least one intermediate plate.

According to one form, the connector is located above and concentric with the at least one fluid manifold.

In accordance with one form, the connector is located above and slightly offset from the at least one fluid manifold.

Other objects, advantages, and features will become apparent from a complete review of the entire specification, including the appended claims and drawings.

## Brief Description of the Drawings

Figure 1 is a perspective view of a stacked plate heat exchanger embodying the present invention;

Figure 2 is a top view of the stacked plate heat exchanger of Figure 1;

Figure 3 is a view taken along line A-A of Figure 2; and

Figure 4 is a view taken along line B-B of Figure 2.

## Detailed Description of the Preferred Embodiments

While the present invention is susceptible of embodiment in many different forms, there are shown in the drawings and will be described herein in detail specific embodiments thereof with the understanding that the present disclosure is to be considered as an exemplification of the principles of the invention and is not intended to limit the invention to the specific embodiments illustrated.

As seen in Figures 1 and 2, a stacked plate heat exchanger 10 embodying the present invention is provided for transferring heat between a first fluid (not shown) and a second

fluid (not shown). The stacked plate heat exchanger 10 as shown in Figure 1, includes a first end plate 12 having a fluid connector 16 drawn from and arranged on the first end plate 12. The stacked plate heat exchanger 10 further includes a second end plate 18 located opposite the first end plate 12, a stack 20 of intermediate plates 22 sandwiched between the end plates 12 and 18 to provide surface areas 24 (best seen in Figures 3 and 4) for transferring heat between the first and second fluids, and a fluid line 26 attached to the connector 16 to direct one of the first and second fluids between the connector 16 and a component other than the connector 16.

As best seen in Figure 3, the connector 16 includes a first cross sectional plane 30 located at a first port 32 of the connector 16 and a second cross sectional plane 34 located at a second port 36 of the connector 16. The first cross sectional plane 30 and the second cross sectional plane 34 form an acute angle 38 relative to each other. The first cross sectional plane 30 is generally parallel to the first end plate 12, while the second cross sectional plane 34 is adjustable to any acute angle 38 relative to the first cross sectional plane 30.

The acute angle 38, as described in the specification and the claims, includes all angles between 0 and 90 degrees. As shown in Figure 3, the acute angle 38 is approximately 50 degrees. Also shown in Figure 3, the fluid line 26 has a bend 40 to minimize the overall height dimension 42 created by the stacked plate heat exchanger 10. The acute angle 38 may be any acute angle as required by a specific application. A larger acute angle 38 approaching 90 degrees eliminates the need for a large bend 40 in the fluid line 26 for situations requiring

a minimized height dimension 42 for the stacked plate heat exchanger 10. The acute angle 38 is preferably between 10 and 70 degrees.

The fluid line 26 is attached to the connector 16 at the second port 36. As shown in the figures, the fluid line 26 is inserted into the second port 36 and is then brazed or soldered thereto. In the preferred form illustrated, the fluid line 26 has a slight bulge that serves as a locating stop when inserting the line28 into the port 36 for brazing or soldering. It should be understood by one skilled in the art that the fluid line 26 may alternatively include a flange (not shown) such that the fluid line 26 is attached over and around the second port 36 and then brazed or soldered thereto.

From the second port 36, the fluid line 26 may extend in any direction as required by the specific application. As shown in Figures 1 and 2, the fluid line 26 extends partially above and over the first end plate 12. Alternatively, the fluid line 26 may extend perpendicularly (not shown) or any intermediate angle relative to the first end plate 12. The fluid line 26 directs one of the first and second fluids between the stacked plate heat exchanger 10 and a component other than the connector 16.

In some applications where the fluid line 26 extends partially above the first end plate 12, it may be beneficial to secure the fluid line 26 to prevent any damage from vibrations or movement adjacent to the stacked plate heat exchanger 20. As shown in Figure 1, the fluid line 26 is attached to the first end plate 12 by an auxiliary support 50. The auxiliary support 50 includes a foot 52 for attaching the auxiliary support 50 to the first end plate 12. In a

preferred embodiment, the first end plate 12 includes a deformation (not shown) having a shape that conforms with at least a part of the auxiliary support 50, such as the foot 52, to position the auxiliary support 50 on the first end plate 12. Conversely, in another preferred embodiment, the foot 52 includes a slight recess or the like (not shown) that receives a protrusion or knob (not shown) formed on the cover plate to facilitate positioning of the support 50 on the cover plate 12. The fluid line 26 may be attached to the auxiliary support 50 by any conventional attachment means such as soldering, brazing, clamping, or the like. Similarly, the auxiliary support may be attached to the first end plate 12 by any conventional means such as soldering, brazing, clamping, or the like. In an alternative embodiment (not shown), the auxiliary support 50 may be formed as an integral piece of the first end plate 12, therefore obviating the step of brazing the auxiliary support 50 to the first end plate 12.

It should be understood by one skilled in the art that the auxiliary support 50 is not required by the present invention. In embodiments where the fluid line 26 does not extend over the first end plate 12, the auxiliary support 50 would not be required. Additionally, the auxiliary support 50 may not be required where additional support is not required. Specifically, the auxiliary support 50 is provided in Figures 2 and 3 for situations where additional supports may be necessary, such as in the engine compartment of an automobile. The auxiliary support 50 is utilized to secure the fluid line 26 and prevent vibrations in the engine compartment from causing leaks at the seam between the fluid line 26 and the second port 34.

The stacked plate heat exchanger 10, shown in Figure 1 including the stack 20 of intermediate plates 2, is merely one embodiment of the present invention. Specifically, the embodiment in Figure 1 is an example of a housingless stacked plate heat exchanger, that can, for example, be used in the engine compartment of an automobile requiring a stack 20 of intermediate plates 22 to transfer sufficient heat between the first fluid, such as coolant, and the second fluid, such as oil.

As is common in stacked plate heat exchangers, the stack 20 includes a fluid manifold 60 defined by aligned and sealed openings 61 in the plates 22 to direct one of the first and second fluids between the intermediate plates 22 and the connector 16. The stacked plate heat exchanger 10 includes additional manifolds 62, 64, and 66 for directing the first and second fluids into and out of the plates 22 of the stacked plate heat exchanger 10.

The heat exchanger 10 includes a plurality of first fluid flow channels 70 and second fluid flow channels 72. The surface area 24 of each plate 22 is located between the first fluid flow channel 70 and the second fluid flow channel 72 to transfer heat between the first and second fluids.

In one embodiment, a first fluid enters the stacked plate heat exchanger 10 via the fluid line 26 through the manifold 60 to the stack 20 of intermediate plates 22. The second fluid enters the stacked plate heat exchanger 10 via a port extending through the end plate 18 to the stack 20 of intermediate plates 22. The first fluid flows between the manifolds 60 and 62 through the first fluid flow channel 70 of each intermediate plate 22 while the second fluid

flows between the manifolds 64 and 66 through the second fluid flow channel 72 of each intermediate plate 22. While flowing through the respective flow channels 70 and 72, the first and second fluids transfer heat thereby cooling one fluid and heating the other fluid. From the manifolds 62 and 66, the first and second fluids flow through respective ports (not shown) in the end plate 18 to exit the stacked plate heat exchanger 10.

It should be understood by one skilled in the art that the above example embodying the present invention may further include connectors similar to connector 16 at each manifold 62, 64, and 66 for directing the first and second fluids. Additionally, fluid lines similar to fluid line 16 may be attached to the additional connectors and may be located partially above and extend over the first end plate 12. One connector 16 is shown for simplicity of the figures.

Additionally, the connector 16, or any other connector utilized as part of the first end plate 12, is positioned so that it is located above and concentric with the respective fluid manifold 60. In an alternative embodiment, the connector 16 may be positioned so that it is located above and slightly offset from the fluid manifold 60.

Optionally, a vent 74 is situated on the first end plate 12 to vent either the first or second fluids. The vent 74 includes a sealing screw 76 for closing and opening the vent 74. In Figure 4, the vent 74 is fluidly connected to the first fluid flow channel 70 to vent any gas that either enters the stacked plate heat exchanger 10 or is created in the first fluid flow channel 70 by the heat transfer. Specifically, after loosening the sealing screw 76, gas

inclusions contained in the fluid can escape. If used as a heat exchanger in an automobile coolant loop, the stacked plate heat exchanger 10 may be positioned at a geodetically overlying point of the coolant loop to vent any inclusions.

The stacked plate heat exchanger 10 may be assembled by stacking the second end plate 18, at least one intermediate plate 22 and the first end plate 12. The exterior of the plates 18, 22, and 12 may then be soldered or brazed together to provide a leak-proof assembly.

The second end plate 18 may be attached to a fastening plate 80 for secure mounting in a desired location. The second end plate 18 may be attached to the fastening plate 80 by any conventional methods such as brazing, soldering, bolting or the like. The fastening plate 80 may then be attached at a desired location using holes 82.

The connector 16 on the first end plate 12 is manufactured using a deep drawing process. A generally flat plate is manipulated by a deep drawing process utilizing several steps to create connection 16 found as part of the first end plate 12, preferably with the port 30 formed during the last step. A 90 degree angle can be created, but is difficult to economically and accurately manufacture as it is much more demanding from a manufacturing standpoint. Therefore, the preferred acute angle 38 is between 10 and 70 degrees.

The stacked plate heat exchanger of the present invention can provide many advantages over traditional heat exchangers. Specifically, the present invention can provide a

stacked plate heat exchanger having at least one integrated connector having an acute angle on a first end plate to achieve a heat exchanger and plumbing system having an overall compact design. By optionally incorporating an auxiliary support, the present invention also supports the fluid line preventing any vibrations or movement from dislodging the fluid line thereby causing a leak.